

CLAIMS

We claim:

1. An ultrasonic probe for removing an occlusion in a blood vessel comprising:

a first terminus at a proximal end of the ultrasonic probe;

a second terminus at a distal end of the ultrasonic probe terminating in a probe tip;

and

a longitudinal axis between the first terminus and the second terminus;

wherein the ultrasonic probe vibrates in a transverse direction generating a plurality of nodes and a plurality of anti-nodes of cavitation energy along the longitudinal axis of the ultrasonic probe to produce an occlusion destroying effect along at least a portion of the longitudinal axis of the ultrasonic probe.

2. The ultrasonic probe of claim 1 wherein a diameter of the ultrasonic probe decreases at defined intervals from the first terminus to the second terminus.

3. The ultrasonic probe of claim 1 wherein a diameter of the ultrasonic probe is approximately uniform from the first terminus to the second terminus.

4. The ultrasonic probe of claim 1 wherein the ultrasonic probe has a flexibility to articulate the ultrasonic probe through the blood vessel.

5. The ultrasonic probe of claim 1 wherein a sheath surrounds at least a portion of the longitudinal axis of the ultrasonic probe.

6. The ultrasonic probe of claim 1 wherein the occlusion is reduced to micron-sized particles.

7. The ultrasonic probe of claim 1 wherein the ultrasonic probe comprises one or more irrigation passages along at least a portion of the longitudinal axis of the ultrasonic probe.

8. The ultrasonic probe of claim 1 wherein the ultrasonic probe comprises one or more aspiration channels along at least a portion of the longitudinal axis of the ultrasonic probe.
- 5 9. The ultrasonic probe of claim 1 wherein a transverse vibration of the ultrasonic probe generates a retrograde flow of debris away from the probe tip.
10. An ultrasonic medical device for destroying an occlusion in a blood vessel comprising:
an ultrasonic probe having a first terminus at a proximal end, a second terminus at a distal end and a longitudinal axis between the first terminus and the second terminus; and
10 a transducer coupled to the first terminus of the ultrasonic probe,
wherein the transducer transfers an ultrasonic energy to the ultrasonic probe creating a transverse vibration along at least a portion of the longitudinal axis of the ultrasonic probe.
11. The ultrasonic medical device of claim 10 further comprising a sheath surrounding at
15 least a portion of the longitudinal axis of the ultrasonic probe.
12. The ultrasonic medical device of claim 10 wherein the transverse vibration creates a plurality of nodes and a plurality of nodes along at least a portion of the longitudinal axis of the ultrasonic probe.
13. The ultrasonic medical device of claim 12 wherein the plurality of nodes are regions of
20 maximum energy emitted by the ultrasonic probe.
14. The ultrasonic medical device of claim 10 wherein the transverse vibration creates a cavitation in a medium surrounding the ultrasonic probe to destroy the occlusion.
15. The ultrasonic medical device of claim 10 wherein the occlusion is reduced to micron-sized particles.

16. The ultrasonic medical device of claim 10 wherein the ultrasonic probe comprises one or more irrigation passages along at least a portion of the longitudinal axis of the ultrasonic probe.
- 5 17. The ultrasonic medical device of claim 10 wherein the ultrasonic probe comprises one or more aspiration channels along at least a portion of the longitudinal axis of the ultrasonic probe.
18. An ultrasonic medical device for removing an occlusion from a vessel comprising:
- 10 an ultrasonic probe having a first terminus at a proximal end, a second terminus at a distal end of the ultrasonic probe terminating in a probe tip and a longitudinal axis between the first terminus and the second terminus;
- a transducer coupled to the first terminus of the ultrasonic probe; and
- a balloon catheter comprising a balloon supported by the balloon catheter,
- wherein the balloon transmits an ultrasonic energy from the ultrasonic probe to the occlusion to remove the occlusion.
- 15 19. The ultrasonic medical device of claim 18 further comprising a sheath surrounding at least a portion of the longitudinal axis of the ultrasonic probe.
20. The ultrasonic medical device of claim 18 wherein the balloon is inflated to engage a wall of the vessel.
- 20 21. The ultrasonic medical device of claim 18 wherein the ultrasonic energy from the ultrasonic probe creates a transverse ultrasonic vibration along at least a portion of the longitudinal axis of the ultrasonic probe.
22. The ultrasonic medical device of claim 18 wherein a transverse ultrasonic vibration of the ultrasonic probe creates a cavitation in a medium surrounding the ultrasonic probe to remove the occlusion.

23. The ultrasonic medical device of claim 18 wherein the occlusion is reduced to micron-sized particles.

24. A kit for removing an occlusion comprising:

an ultrasonic probe having a first terminus at a proximal end of the ultrasonic probe, a second terminus at a distal end of the ultrasonic probe and a longitudinal axis between the first terminus and the second terminus;

a sheath sized to surround at least a portion of the longitudinal axis of the ultrasonic probe; and

instructions for assembling and tuning an ultrasonic medical device.

25. The kit of claim 24 further comprising packaging wherein the ultrasonic probe and the sheath are pre-sterilized and sealed against contaminants.

26. The kit of claim 24 further comprising a container for the ultrasonic probe.

27. The kit of claim 26 wherein the container complies with regulations governing the storage, handling and disposal of a sharp medical device.

28. The kit of claim 26 wherein the container comprises a single use locking mechanism.

29. A method of removing an occlusion from a blood vessel comprising:

providing an ultrasonic probe having a first terminus at a proximal end of the ultrasonic probe, a second terminus at a distal end of the ultrasonic probe and a longitudinal axis between the first terminus and the second terminus;

inserting the ultrasonic probe into the blood vessel;

moving the ultrasonic probe to a site of the occlusion; and

activating an ultrasonic generator coupled to the ultrasonic probe,

wherein the occlusion is removed in areas adjacent to a plurality of energetic nodes produced along a portion of the longitudinal axis of the ultrasonic probe, the plurality of energetic nodes generated from a transverse vibration of the ultrasonic probe.

- 5 30. The method of claim 29 further comprising irrigating the site of the occlusion by at least one irrigation passage located along at least a portion of the longitudinal axis of the ultrasonic probe.
31. The method of claim 29 further comprising aspirating the site of the occlusion by at least one aspiration channel located along at least a portion of the longitudinal axis of the ultrasonic probe.
- 10 32. The method of claim 29 further comprising reducing the occlusion to micron-sized particles by the transverse vibration.
33. The method of claim 29 further comprising transmitting an ultrasonic energy from the ultrasonic generator by a transducer engaging the first terminus of the ultrasonic probe to transversely vibrate the ultrasonic probe.
- 15 34. The method of claim 29 further comprising providing an imaging device to view the ultrasonic probe.
35. The method of claim 29 further comprising providing a sheath surrounding at least a portion of the longitudinal axis of the ultrasonic probe.
- 20 36. The method of claim 35 wherein the sheath comprises an at least one irrigation channel.
37. The method of claim 35 wherein the sheath comprises an at least one aspiration channel.
38. The method of claim 29 further comprising providing the ultrasonic probe having a flexibility allowing the ultrasonic probe to be articulated in the blood vessel.
39. A method for destroying an occlusion in a blood vessel comprising:

providing an ultrasonic probe having a first terminus at a proximal end of the ultrasonic probe, a second terminus at a distal end of the ultrasonic probe and a longitudinal axis between the first terminus and the second terminus;

providing a balloon catheter having a balloon supported by the balloon catheter;

5 inserting the balloon catheter proximal to the occlusion;

inserting the ultrasonic probe through the balloon catheter and moving the ultrasonic probe proximal to the occlusion;

inflating the balloon of the balloon catheter to engage the balloon with a wall of the blood vessel;

10 activating an ultrasonic generator engaged to the ultrasonic probe to provide an ultrasonic energy to the ultrasonic probe creating a transverse ultrasonic vibration of the ultrasonic probe,

wherein the balloon transmits the ultrasonic energy from the ultrasonic probe to the occlusion to destroy the occlusion.

15 40. The method of claim 39 further comprising providing a sheath surrounding at least a portion of the longitudinal axis of the ultrasonic probe.

41. The method of claim 39 further comprising reducing the occlusion to micron-sized particles by the transverse ultrasonic vibration of the ultrasonic probe.

20 42. The method of claim 39 wherein the balloon of the balloon catheter is inflated to a pressure to maintain engagement between the balloon and the wall of the blood vessel.

43. The method of claim 39 further comprising providing an imaging device to view the ultrasonic probe.

25 44. The method of claim 39 wherein the transverse ultrasonic vibration creates a plurality of nodes and a plurality of anti-nodes along at least a portion of the longitudinal axis of the ultrasonic probe.